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FIBER OPTIC CABLING MANAGEMENT USING HOOK AND LOOP FABRIC

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BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to telecommunications equipment and, more particularly, to the management of fiber optic cables using hook and loop fabric.

Description of the Related Art

In the telecommunications and data transmission industries, optical fibers, rather than metal cables, are used increasingly to transmit signals. The technology uses glass or plastic threads (fibers) to transmit data. A fiber optic cable consists of a bundle of threads, each of which is capable of transmitting messages modulated into light waves. Fiber optic cables are utilized in communication systems for carrying information between communication sources and sinks. An example of a communication system that utilizes fiber optic cable is an optical cross connect for a communications network

Optical cable management has become a major concern in the design of telecommunications equipment. Fiber optic cable typically includes at least one glass core for optical, high bandwidth transmission of information. Typically, fiber optic cable requires a minimum bending radius (e.g., a one-inch bending radius) to avoid damaging the glass core and to avoid producing a large dB loss in the transmission of information through the cable. Therefore, optical cabling must be handled and stored to carefully avoid tight bends and kinks in the cabling.

The use of optical fibers to transmit data in the telecommunications industry has grown dramatically in recent years. With the increased use of optical fiber transmission paths, the industry has experienced a dramatic need for new and improved ways to effect fiber optic connections efficiently and with as little overhead costs as possible. This need

becomes more critical and difficult to meet in newer systems that require increasingly large numbers of cables to be efficiently housed in a relatively small space. The high density of such systems creates a need for an organizational system that provides convenient access to the cables in order for technicians and test personnel to readily access a particular cable that needs to be removed, replaced, or otherwise accessed. By density, it is meant the number of locations per unit volume or unit area for providing connections between fiber optic cables on the chassis.

SUMMARY OF THE INVENTION

An apparatus is provided that uses hook and loop type releasable engagement to support cables. The apparatus includes a substrate and a cable fastener. The substrate has a first surface that contains one of a plurality of hook and loop mechanisms. These mechanisms may be hooks, mushroom-shaped stems, pine-tree shaped stems, or loops. The cable fastener is capable of releasable engagement to the substrate by means of a hook and loop connection. The tie wrap contains another of the hook and loop mechanisms to effect the releasable engagement. The cable fastener is shaped to be capable of defining a variable-width opening. In the preferred embodiment, the cable fastener is shaped to define an elongated body and an oval-shaped head. The head has an interior opening that accommodates pass-through of the elongated body to form a loop around the cables.

A method of managing cable is also provided. The method includes the steps of supporting one or more cables with a cable fastener and releasably engaging the cable fastener to a substrate. The cable fastener is shaped to be capable of defining a variable-width opening and contains one of a plurality of hook and loop mechanisms. The substrate contains another of the plurality of hook and loop mechanisms.

An apparatus that manages cable is also provided. The apparatus includes a cable fastener means for supporting one or more cables and a substrate means for releasably engaging the cable fastener means. The cable fastener means also includes a means for releasable engagement. In at least one embodiment, the cable fastener means includes a means for encircling the one or more cables such that each of the one or more cables is squeezed into contact with at least one other of the one or more cables.

An apparatus is also provided wherein the apparatus includes a rigid frame, a planar substrate, and a tie wrap. The rigid frame is capable of accommodating a plurality of cables and has at least one planar surface. The planar substrate has a first surface and a second surface, the second surface being coupled to the planar surface of the frame. The first surface of the planar substrate includes a plurality of engagement mechanisms. The tie wrap contains loops capable of engaging the engagement mechanisms of the substrate, wherein the tie wrap is capable of being releasably engaged to the substrate by means of a hook and loop connection. The tie wrap is shaped to define an elongated body having a predetermined width. The tie wrap is further shaped to define a head portion having a width greater than the predetermined width of the body. The head portion is shaped to define an opening through which the body of the tie wrap may be pulled.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be better understood, and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

FIGURE 1 illustrates a plan view of a prior art cable duct.

FIGURE 2 illustrates a cable system incorporating a prior art cable duct.

FIGURE 3 illustrates a cable system incorporating a prior art cable duct.

FIGURE 4 illustrates a cross-sectional view of a prior art cable duct.

FIGURE 5 illustrates a cable system incorporating a cable management apparatus according to at least one aspect of the present invention.

FIGURE 6 illustrates a plan view of a cable management apparatus according to at least one aspect of the present invention.

FIGURE 7 illustrates a cross-sectional view of a cable management apparatus according to at least one aspect of the present invention, as installed on a frame.

FIGURE 8 illustrates a tie wrap according to at least one aspect of the present invention.

FIGURE 9 illustrates a cross-sectional view of a cable management apparatus according to at least one aspect of the present invention.

DETAILED DESCRIPTION

The following sets forth a detailed description of a mode for carrying out the invention. The description is intended to be illustrative of the invention and should not be taken to be limiting.

FIGURES 1 and **2** illustrate prior art cable ducts **100, 200.** Cable ducts **100, 200** are widely used to guide, support, and separate cabling and are considered an industry standard. The ducts **100, 200** are constructed of a rigid material, such as commercial-grade plastic, and have a rectangular cross section with a removable lid **102** to protect the cabling **104, 204**. In traditional systems, cable ducts **100, 200** are adequate to separate and support cables.

FIGURE 2 illustrates a dense system that utilizes a cable duct **200**. **FIGURE 2** illustrates a plurality of cables **204** that are routed through the duct **200** and that have one end terminating at a connector **202**. When a large number of cables **204** are routed through a traditional duct **200**, the cables extend beyond the top of the duct. This makes it very difficult, if not impossible, to install the lid **102** (**FIGURE 1**). In a dense system, even if the lid **102** (**FIGURE 1**) is installed, the lid easily pops off when cable ducts are full (and also during temperature cycles). In contrast, when a lid is installed on a cable duct containing cables, a squeeze factor is often introduced that pushes the cables into contact with each other and into contact with the sides of the cable duct **200**, thereby providing support for the cabling **204**. Of course, if the cable duct **200** is not completely full, then it is unable to provide all-around support of cables **204** via this squeezing action, even with the lid on.

FIGURE 2 illustrates that using a traditional cable duct **200** for a dense cable system presents both protection concerns and support concerns. The rigid rectangular-shaped ducts **200** cannot conform to the cables and thus have difficulty accommodating the required volume of cables for dense systems. Cables that extend beyond the top of the duct **200** are unsupported and unprotected. If the lid **102** (**FIGURE 1**) cannot fit onto the duct **200**, then even cables that lie within the duct **200** are unprotected on one side.

Lack of support for cables is undesirable. When vibration occurs, such as that incident to moving or shipping a telecommunications system or vibration incident to seismic activity, the weight of unsupported cables **204** pulling against the connector **202** can unseat the connector **202**. In addition, excessive vibration can damage the fragile glass fibers within the cables **204**. Another concern with unsupported cables that extend above the edge of a cable duct is the stress they can put on the cables underneath them. For instance, if a stress such as a jolt causes the top cables to momentarily move up into the air and jar back down, the dislodged cables bang on the lower cables when they come back down. This can cause damage to the lower cables even though they lie within the protection of the cable duct **200**. Unsupported cables are also at risk of being damaged during transportation, manufacturing tests, and environmental operation if they are permitted to move in such a way that they bump into contact with other cables.

FIGURE 4 illustrates an additional support limitation of traditional cable ducts **402**. Even when the lid **406** is installed, the traditional duct **402** and lid **406** can only provide partial support for cables **404** that flex within the duct **402**. **FIGURE 4** illustrates that cables, such as cable **404a**, that are located at the top of the bundle's flexing arc, are supported by the rigid interior walls of the cable duct **402** only at one point at the approximate mid-point of the flexing arc. Cables, such as cable **404n**, that are located at the bottom of the bundle's flexing arc, are supported only at the outside edges **408**, **410** of the cable duct.

Another difficulty with traditional cable duct systems arises from the fact that the lid of the entire cable duct must be kept open (cover off) during assembly or repair until all cable placement or repair is complete. With dense high-volume cable systems it is difficult to keep the completed cabling from falling out of the ducts while additional cabling is being added or repaired.

FIGURE 3 illustrates that another difficulty arises from the fact that the rigid edges of the cable duct **300** are prone to damaging cables **304** that must negotiate sharp turns at the edge **302** of the cable duct **300**. When the weight of the cables **304** rests on the sharp edge **302** of the duct **300**, damaging kinks can occur in the cables **304**. Many cables **304** cannot operate when bent in a radius of less than one inch, yet are required to make sharp 90-degree turns at the edge **302** of a traditional cable duct **300**. Such a kink or a too-

sharp turn can result in a catastrophic defect in the cable **304**. Another undesirable effect produced by having the weight of the cables **304** all supported by the edge **302** of the cable duct **300** is that the pressure of and weight of the cables **304** can cause the rigid plastic cable duct **300** to buckle and/or break.

FIGURE 5 illustrates exemplary plastic tie wraps **505** that are often used in traditional cable systems to wrap bundles of cables **503**. These wrapped cables **503** are either attached to cable trays or some other structure. Cable tie wraps are often affixed to a system housing at pre-placed snaps or pre-drilled holes. Other cable tie wrap solutions utilize self-adhesive attachment. These schemes are limited in terms of where cables can be placed and how much cable weight they can support. The snap-in cable tie wraps can support a relatively large cable weight, but they must interact with pre-placed holes or other support devices. This arrangement does not accommodate complete flexibility in the placement of cables within a system. As the telecommunications system evolves through upgrading or up-scaling, the pre-placed support devices may become even less optimum. Cable tie schemes that are self-adhesive can sometimes overcome this type of placement restriction. On the other hand, the self-adhesive backing is usually a relatively small cross-section. As systems are scaled up or upgraded to accommodate additional cables, the weight of the cables can overcome the strength of the adhesive.

FIGURE 5 illustrates a cable management apparatus **500** according to one aspect of the present invention. The cable management apparatus **500** allows for flexible routing of cables within the system. The cable management apparatus **500** includes a substrate **502** and at least one cable fastener **504** that are capable of releasable engagement with each other. The cable fastener **504** can be any mechanism that can be made to encircle cables and conform to their width. For instance, the cable fastener could be a ring of plastic, fabric, string, or other malleable material, wherein the ring is of a construction that allows variable diameter sizing. One such embodiment would be an elastic ring coupled to an elongated body. In the preferred embodiment, the cable fastener **504** is a tie wrap as described below in connection with **FIGURE 6**.

While the substrate can be of any shape, including tubular, in the preferred embodiment the back side of the substrate **502** is planar. The substrate **502** is sized and shaped to accommodate coupling to a frame **506** or other supporting structure. In at least

one embodiment, the frame **506** is a rigid rectangular-shaped frame that is configured to support and manage a relatively large number of fiber optic cables to provide a dense cable system. The back side of the substrate **502** is coupled to the frame **506** by any conventional means, including adhesive, screws, and rivets. In at least one embodiment, the substrate **502** is coupled to the frame **506** in substantially the same position that a traditional cable duct **200** (**FIGURE** 2), **300** (**FIGURE** 3) would be placed, including both horizontal and vertical cable routing surfaces.

The substrate **502** is a piece of a hook and loop sheet material. As used in this application, "hook and loop" is used in a generalized sense to mean any of several reclosable fastening materials, such as Velcro™. While referred to as "hook" and "loop", the substrate **502** material need not necessarily comprise hooks or loops, but rather contain any of several engagement mechanisms. For instance, in the preferred embodiment, a flame-retardant industrial-grade material produced by 3M™ is used for the substrate **502**. The material contains only the equivalent of "hooks," but they are not actually hooks. The material, known as Dual Lock™, is a polypropylene material containing hundreds of mushroom-shaped stems per square inch. When two pieces of Dual Lock™ material are pressed together, the mushroom-shaped stems interlock with each other, creating a separable bond. Alternative versions of Dual Lock™ materials provide pine-tree-shaped stems. A flame retardant Dual Lock™ fastener is further described in U.S. Patent Number 5,691,021 issued to Kobe. As used herein, the term "hook and loop" is intended to encompass Velcro™, Dual Lock™, and any other similar material that provides a means for creating a releasable engagement bond.

FIGURE 5 also illustrates the tie wraps **504**. The tie wraps **504** are used to surround cable bundles, thereby providing separation and support for the cables **508**. While they could contain any of the hook and loop type mechanisms described above (loop, hook, mushroom-shaped stem, pine-tree-shaped stem, etc.), the tie wraps **504** of the preferred embodiment are constructed of a material containing loops that create a separable bond when pressed into contact with the mushroom-shaped stems of the substrate **502**.

Figure 6 illustrates a tie wrap **504** surrounding a bundle of cables **508** and connected to the substrate **502**. **FIGURE 6** illustrates that the tie wrap **504** is better able

than the rigid cable ducts **200, 300** (**FIGURE 2** and **FIGURE 3**, respectively) to conform to the size and shape of the cable bundle.

FIGURE 7 is a cross-sectional view, illustrating that the cables **508** in a bundle, when fastened by a tie wrap **504**, are well –supported. The tie wrap **504** can be pulled tight around the cables, compressing the cables and causing each cable to be in supporting contact with at least one other cable and, in some cases, with the tie wrap **504** itself.

FIGURES 8 and **9** illustrate a tie wrap **504** in detail. The tie wrap **504** is composed of a material having a means (such as hooks, mushroom-shaped stems, pine-tree-shaped stems, or loops) to effect a releasable engagement bond with the substrate **502**. In the preferred embodiment, the tie wrap **504** contains loops that are configured to create a releasable bond when pressed into contact with the mushroom-shaped stems of the substrate **502**. The tie wrap **504** includes an elongated body **802** and a head portion **804**. The head portion **804** is substantially oval in shape and has outer edges that are shaped to define an interior opening **806**. The head portion **804** is wider than the width of the body **802**. One skilled in the art will recognize that alternative shapes will also accomplish the desired function, including round and rectangular-shaped heads.

FIGURE 9 illustrates that head portion **804**, being wider than the body, is sized such that the body can be pulled through the interior opening **806**, thereby creating an encircling support structure for a bundle of cables **902**. The loop structures of the body **802** are pressed into contact with the hook structures of the substrate **502**, creating a releasable interlocking bond.

Returning to **FIGURES 5** and **6**, one can see that the engagement of the tie wrap **504** with the substrate **502** creates a cable management apparatus **500** that provides support and a means of segregation for the cables **508**. The cable management apparatus **500** allows cables to bend at a more gradual angle than cables entering a traditional cable duct **300** (See **FIGURE 3**). The cable management apparatus **500** provides the flexibility to place cables wherever they are needed within the frame **506**, while providing a high level of support for the cables **508**.

Flexibility is achieved by permitting a large number of cables to be bundled without the sacrifice in support that is required to accommodate a large number of cables within a traditional cable duct **300** (See **FIGURE 3**). Additional flexibility is afforded by the fact that the cable management apparatus **500** permits cables bundled with tie wraps **504** to be placed at interim locations along the substrate **502**. In contrast, traditional cable ties can only be placed at locations that provide a support mechanism such as a pre-drilled support hole. This pre-placement of support mechanisms does not afford the flexibility in cable support placement that is realized by the cable management apparatus **500** described herein.

The elongated body of the tie wrap **504** provides for a relatively large support surface for the bundled cables **508**. The high surface area of contact between the body of the tie wrap **504** and the substrate **502** provides stronger support than traditional tie wraps that are supported with adhesive. Such traditional adhesive systems are limited in the amount of cable each tie wrap can support. An adhesive-backed tie wrap support provides a relatively small surface area of adhesive to support the cable weight. In dense systems, the weight of the cables can overcome the adhesive.

The cable management apparatus **500** also provides advantages in cabling systems that have different types of cables that must be segregated. For instance, some systems include both electrical and fiber optic cables that must be segregated from each other. The cable management apparatus **500** allows for such separation, providing for power cable bundles to be anchored down to the substrate **502** along side, but separate from, fiber optic cable bundles. It should be noted that the cable management apparatus **500** is intended to be used with any elongated cable-like materials including metal cables, fiber optic cables, electrical cords, wires, ropes, and the like.

Regarding installation and repair of cables, the cable support apparatus **500** provides distinctly advantageous features. The tie wraps **504** can be placed at several interim locations along the length of a cable bundle. The cables **508** can be accessed for repair simply by disengaging the tie wrap **504** from the substrate **502** and removing the body **802** (**FIGURE 8**) from the interior opening **806** (**FIGURE 8**). During installation of additional cables, the entire length of existing cables need not be exposed, as would be necessary when removing the lid from a traditional cable duct. Instead, one tie wrap at a

time may be disengaged along the length of existing cables as new cables are installed. This permits cables to be supported at intervals so that assembly can move much more quickly without requiring unsupported exposure for the length of already-installed cables.

While particular embodiments of the present invention have been shown and described, it will be recognized to those skilled in the art that, based upon the teachings herein, further changes and modifications may be made without departing from this invention and its broader aspects and, thus, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of the invention.